Mr. Lesley announced the discovery, just made, of a remarkable lignite deposit, close to the ore-banks of the Mont Alto Furnace, in Franklin County, Pennsylvania; but owing to the lateness of the hour, begged leave to postpone the exhibition of the specimens on the table, and the description of the deposit, to the next meeting.

The stated business of the meeting being called for, the Treasurer's report was read, and regularly referred to the Finance Committee.

The report of the Publication Committee was read, and referred to the Finance Committee.

The report of the Board of Officers on the application of "Torricelli" for the Magellanic premium was read, and, on motion of Mr. Fraley, it was resolved, that the subject be ordered for discussion at the next meeting of the Society, and that notice be given to the members on the cards, and an advertisement be made for three days before the meeting, in two daily newspapers.

New nomination No. 529 was read.

And the Society was adjourned.

Stated Meeting, December 16*th*, 1864.

Present, twenty-one members.

Dr. Wood, President, in the Chair.

A letter declining the appointment to prepare an obituary notice of Prof. Silliman, was received from Prof. Pierce, dated Cambridge, December 18th, 1864.

lately published paper on the structure of the prairies; wherein he argues that the prairie deposit was made in a preglacial lake, overspreading the whole Valley of the Mississippi, as far south as Middle Alabama. *Sill. Jour.*, Nov., 1864. Sec.]

Letters of acknowledgment for publications received were read from the Lombardy Institute; R. Saxon Society; Herr Jochmann; the R. Danish Society; the N. H. S. at Emden; the R. Academy at Amsterdam; Batavian Society at Rotterdam; Sir John Herschel; the Lords of the Admiralty; the Society of Arts, and Society of Antiquaries of London; the Natural History Society of Northumberland; the Smithsonian Institution; and the Chicago Historical Society.

Letters of invoice were received from the Societies at Leipsic, Emden, Upsal, Copenhagen, and the Academy at Amsterdam.

Donations for the Library were received from the Royal Societies and Academies at Upsal, Copenhagen, Leipsic, Emden, Amsterdam, Rotterdam, Milan, London, and Dublin; from the German Geological and French Geographical Societies; from Friedlander & Son of Berlin; and Fr. Miller of Amsterdam, booksellers; from Prof. Steenstrup of Copenhagen; Prof. Zantedeschi of Padua; and Elia Lombardini of Milan; from the London Chemical Society, and Sir John Herschel; from the American Academy at Boston; and Essex Institute at Salem; J. E. Cooley, bookseller; and James T. Hodge, geologist, of New York City; the Academy of Natural Sciences, at Philadelphia; the Franklin Institute, and Mr. M. C. Lea.

The Librarian was authorized to complete the set of Proceedings for Sir John Herschel, at his request.

On motion of the Librarian, after reading a letter from Prof. Daniels of Chicago, the Academy of Science at Chicago was placed on the corresponding list.

The death of one of the oldest members of the Society, Mr. Ross Cuthbert, of Berthier (Lanorais), Lower Canada, was reported by the Secretary, on the authority of a private letter from Prof. Hunt of Montreal, as having taken place in 1861.

The death of another member of the Society, Mr. Henry Rowe Schoolcraft, in Washington, on the 11th inst., aged 72, was announced by the Secretary.

Prof. Cresson was excused from preparing an obituary notice of Mr. Waln.

Mr. T. P. James read a paper on the New Mosses which he had detected within the limits of the United States, east of the Mississippi River, intended for the Transactions. On motion the paper was referred to a Committee consisting of Messrs. Durand, Porter of Lancaster, and Aubrey H. Smith.

Mr. Lesley described a recent discovery of Lignite in iron ore at Pond Bank, ten miles east of Chambersburg, in Franklin County, Pennsylvania, and described the importance of the discovery in a theoretical point of view, its analogy with the Brandon deposit in Vermont, and its influence on the determination of the age of the present surface of the land. Specimens from the deposit were exhibited to the members. Mr. Lesley said:

A few days ago, a remarkable instance of the discovery of a tertiary deposit among the Appalachian mountains, similar to that of the celebrated Brandon lignite deposit, in Vermont, has occurred in Southern Central Pennsylvania. The geological importance of these two cases, so far as I am aware the only two on record, can hardly be overestimated. They open again, in the most embarrassing manner, the discussion of the age of the present Silurian, Devonian, and Carboniferous surface. They suggest an entire revolution in the generally accepted modes of regarding the production of our Appalachian topography. They lend a novel interest to the glacial hypothesis; and they help to settle our views on the difficult subject of the confinement of the New Red within its well-known limits, along the south foot of the South Mountain or Blue Ridge range, which I discussed in a brief manner, at the last meeting of the Society.

The lignite was struck in a shaft, at a depth of 40 feet below the surface. It was between 4 and 5 feet thick; under it a stratum of very solid gray sand,* of equal thickness (5–6 ft.); and then lignite more solid and glossy, for seven feet more, to the bottom,† as far as sunk. I have not been able to visit the place, and give this description as it is reported by the shaft-sinker. Large logs of wood were taken from the deposit, specimens of which, I have the pleasure of

* ("Like disintegrating sandstone.")

† ("With here and there a thin streak or vein of hard gray sand.")

exhibiting to the members present. The rings of growth, the rays, and the bark fibre, are as visible as in a fresh butt. The wood is converted partly into a brilliant cannel coal, and the rest of it into common brown coal. No leaves or fruit have as yet been noticed by the workmen; although such may have been overlooked, from want of knowledge of their importance.

It is possible that a large body of this material may exist just where the shaft happened to be sunk; for the Brandon deposit is a mass about 25 (twenty-five) feet square, descending steeply through a hundred fold larger mass of white clay, to a depth of at least 100 (one hundred) feet. But we cannot call it a large body *comparatively* speaking. It is scarcely larger than the trunk of a single one of the giant trees of California; a mere plug of coal thrust vertically downward into a mass of clay. But Prof. Hitchcock expresses the opinion that the Brandon deposit is not "a vertical plug," but a fragment of a regularly steep-dipping stratum of lignite. He dissents expressly from my own view of the case (published in 1857, after I had visited the locality), when he says: "Mr. Lesley imagines that the Brandon deposit is in a hole, like that in Balamacadam, in Ireland. But if he will visit the former, he will find it no more and perhaps rather less in a hole than the other analogous deposits scattered for two hundred miles along the west base of the Green Mountain range. They generally occur in depressions in the limestone floor, or in sheltered valleys, and this is probably why the drift agency did not sweep them away."*

The venerable and candid geologist whose loss we have been called upon so recently and so heartily to deplore, would have taken, perhaps, more delight in the discovery near Chambersburg, than any other man living; and I regret with a very sad feeling the impossibility of comparing notes with him once more upon this old ground of dispute. For he would probably now be convinced that the different facts involved in this phenomenon must be separated; and that we have to keep our eyes open to several collateral but independent trains of geological accidents. The Lignite and the Iron-ore are neither of the same age, nor, strictly speaking, possessed of any structural attribute common to both. I have, therefore, regarded only the lignite deposit as "in a hole;" not by any means the iron ore. This latter I have long ago described as continuously stratified. When Dr. Hitchcock, therefore, in the above quotation from his report, says, that I will find it no more and perhaps less in a hole than the

* Geology of Vermont, 1861, page 238, lines 4–6.

other analogous deposits, &c.," he cannot mean to affirm anything of the lignite; for there are no other analogous *lignite* deposits known, except only the ore which I bring to the notice of the Society to-night. And I expect to receive the evidence, that it also is truly "in a hole;" that is, it will probably be found to be as curious an exception to all the rest of the phenomena of the whole belt of hematite deposits of the Great Valley, for many hundreds of miles in Pennsylvania and Virginia, as the little plug of lignite at Brandon is an exception to all the other features not only of the great Brandon ore bed, but of all that belt of similar ore beds which ranges for several hundred miles through Vermont, Massachusetts, and New York.

Geologists will appreciate the assertion that it is the extreme rarity of these lignite apparitions in one of the most wonderfully continuous, extensive and valuable ore belts of the world, that gives them all their importance, and produces all our embarrassment. It is therefore of prime importance to make sure of this fact, viz., of the actual rarity of the presence of lignite, or its equivalents, in the ore deposits, and to keep this rarity always in mind, in discussing the age of the ore belt itself; but this Dr. Hitchcock has not done.

On pages 234–236 of the Vermont Report, he says: "Wherever we have found brown hematite and manganese, or beds of ochre, or pipe clay, white, yellow or red, in connection with coarse sand or gravel, all lying beneath the drift, and resting on the rocks beneath, we have regarded the deposit as an equivalent of that at Brandon just described, even though not more than one or two of the substances named be present." The peculiar feature of the Brandon mine is therefore ignored by being confused with others, common to the whole belt.

Dr. Hitchcock gives a list of 26 such deposits along the western side of the Green Mountain range, premising that: "from Stamford through Bennington, as far as Middlebury, it would probably not exceed the truth to represent it as a continuous narrow belt. North of Middlebury the localities are few, perhaps from denudation." Yet along this "probably continuous" belt, he can enumerate, with exception of the Brandon mine, only *one*, that of East Bennington, which exhibits even so much analogy to a lignite deposit as "pipe clay with numerous stems of plants;" and only six others, wherein white clay, ochre, ochres and clay, or lithomarge, suggest to his mind an analogy with the Brandon kaolin.

Now it is quite as safe to call the continuation of the line of the Vermont ore deposits, through Massachusetts, New York, New Jer-

sey, Pennsylvania, Maryland, Virginia, and East Tennessee to Alabama, "a narrow continuous" belt; for, with one exception, hereafter to be described, it is really such. And it would be quite as difficult to point out another deposit strictly "analogous to the Brandon lignite," along all these many hundred miles, excepting the one just discovered in Southern Pennsylvania. There may be others not yet made known. But a great number, literally thousands of shafts, and open quarries, have been made in this ore belt in these different States, during the last hundred years, from some of which hundreds of thousands of tons of stuff have been excavated; and yet even the presence of a fossil leaf, or any other slight trace of tertiary vegetation, is almost or quite unknown. Quantities of dark and even black clay have been obtained; but in all instances, so far as I am aware, the coloring matter has been manganese rather than carbon. The future may reveal much which we do not expect; but enough has been done to prove the rarity of lignite in the ore belt.

We must therefore carefully separate these sporadic occurrences of lignite from the general occurrence of iron ore, in our discussion.

I think it can be shown, also, that we must keep quite as separate the lignite and the clays. And I think it can also be shown that the clays are to be connected closely with the ores, instead of with the lignite, if we are to reach clear views of the whole phenomenon.

These are the principal features of the great ore belt of the Atlantic States:

1. It occupies a narrow strip of surface, along the Great (Lower Silurian) Valley, which begins in Canada, and ends in Alabama.

2. It hugs the southeastern margin of the Great Valley, and lies at and against the foot of the Mountain Barrier, which, as is well known, shuts the Great Valley in from the Atlantic seaboard; a barrier, known by various names, such as the Green Mountains, the Highlands, the South Mountains, the Blue Ridge, and the Smoky Mountains; but which is in reality and geologically considered, one continuous range or ridge of rock.

3. It lies, therefore, over the lower contact of the Lower Silurian limestones with and upon the rocks of the Great Barrier range; and is, therefore, *in some way or other*, genetically involved in that contact. It therefore belongs geologically to the Lower Silurian limestone formation, and especially to the lowest member of that formation; and cannot in any sense, *as an ore belt*, be of tertiary age, without a plain violation of the canons of structural geology.

4. It consists everywhere of two parts, more or less easily dis-

tinguished; the one stratified in the same sense as the Silurian limestones themselves; the other a surface-wash over the basset edges of the first. The date of the formation of this local surface-wash may be tertiary, and perhaps post-tertiary. The stratified portions must be, as to their stratification, of Lower Silurian age; while the metamorphism which they have undergone, *in situ,* productive of stratified clays and ores, *may date from any time subsequent to the formation of a surface topography approximately identical with that which now exists.* The actual change of the original Lower Silurian calcoferriferous sandstones and slates, *in situ,* at their outcrops, into limonite clay beds, *in ipso situ,* stratified as before, but charged with an additional percentage of the oxides from a former higher surface now eroded, and with this extra charge of iron and manganese carried by percolation down to and crystallized against their foot rock,—this change may have required an immense time to perfect, and no doubt was going on, *pari passu* with the degradation of the surface by slow erosion, from higher to lower levels, until it stands at the level of the present day.

This long era of *iron ore concentration,* in the Lower Silurian slates, could not have commenced until after the close of the coal era; and I will be able to show, I think, not until after the close of the New Red or Middle Secondary age. It may have been commensurate with the Cretaceous, Tertiary and Recent periods together; or with the Tertiary or the latest Tertiary and Recent alone. But it seems more likely, in view of the geographical relationships of the New Red to the Silurian on one side of it, and to the Cretaceous on the other side of it, that the erosion of the surface commenced at the close of the New Red era, and continued without intermission down to the present day. There is no sufficient evidence of the submergence of the Atlantic side of the Continent, since its emergence after the coal. There is not a trace of New Red, Cretaceous, or Tertiary deposit recorded by any geologist, so far as I am aware, over all the country back of the Great Barrier range, from west of the Hudson, until we reach the prairie lands of the Mississippi Valley. There were, of course, New Red rivers, Cretaceous brooks, Tertiary freshets, Glacial ice; but these carved out the present surface-topography of the Appalachians, without leaving a plant, an animal, or even a pebble which can be recognized as belonging to any special age. In fact, the New Red surface must have been largely remodelled, lowered, and denuded of New Red relics, by the Cretaceous agents; and the same liberties were no doubt taken with the

surface of the Cretaceous age, by the sweeping and garnishing artists of Tertiary times. Little by little the whole sloping mean horizon of water-level, from the Alleghany Mountain to the South Mountain, was lowered to its present line. The gaps were gradually deepened, widened, and rounded off to correspond with the slow deepening of the limestone and slate valleys behind them; and the long strait narrow sandstone crests of the mountains of IV and X and XII (Middle Silurian, Upper Devonian, and Carboniferous), were gnawed away evenly at a slower but not less steady rate.

It was Professor Rogers's opinion that all this was, so to speak, the work of a moment; the consequence of the rush of a large body of water over the face of the Continent, at the time when the coal era was abruptly brought to a termination by the upheaval into the air of the whole Appalachian belt of earth-crust, when it was thrown into waves or folds; after which the once horizontal strata remained partly or entirely upright.

With this cataclysmic hypothesis I cordially sympathized for some years; and some of the geologists of the Pennsylvania survey, I believe, still do so. Nor am I yet entirely convinced,—it may be from the force of a strong and early prejudice,—that such a cataclysm is not indispensable to explain the earlier and perhaps the larger part of the whole phenomenon. Not that I ever accepted that part of Mr. Rogers's statement of it which gave an account of the *modus operandi* of the anticlinals, viz.: by a pulsating planetary lava-nucleus. But the study of the surface itself, covered with mountains and valleys, arranged in a beautifully symmetrical manner, by whatever energy you please,—and I have always thought the lateral thrust of a cooling and shrinking crust one sufficiently plain and precisely explanatory of the details,—in fact, the study of these details, some of which offer the most inviting problems of erosion to the structural geologist, has impressed upon my mind the conviction that aërial and fluvial agents are not the *kind* which could have *begun* the great work of Appalachian erosion. Give them time and they are omnipotent, I grant, *but only in their own sphere.*

It would lead too far to argue this part of the subject here. I only wish, when I describe the whole water-shed horizon of the Appalachians as being step by step lowered during later Secondary, Tertiary, and Quaternary times, to guard against that total rejection of cataclysmic agency which has come to characterize the geological speculation of the present day upon great structural questions. This fact, evidently true in itself, is also necessary to the argument respecting

the Tertiary age of the iron ore beds containing lignite. In fine, it is the main fact of the discussion.

The gradual lowering of the main surface-plane involved, 1st, the obliteration of all grand original inequalities which would have been produced by a grand original cataclysm, if a cataclysm be allowed; and, 2d, the production of a new set of inequalities, due partly to structural relations of movement, such as folds and faults, but chiefly to the different *homogeneousness*, the different *compactness*, and the different *insolubility* of the formations. These three chemical and lithological differences, of course, produced our present mountain, hill, and valley surface. It is evident, then, that the reason why the southeast side of the Great Valley is everywhere lower than the northwest side, is because it represents the more soluble and less compact outcrop edges of the Lower Silurian limestones No. II, while the other, or northwest side of the Great Valley, consists of Lower Silurian slates No. III. In fact, the Great Valley may be said to be as to the northwest half of it paved with low hills. These are the slate hills of that half of the valley which lies up against the North (Kittatinny, Blue or Brush) Mountain. The southeast half is a nearly perfect plain, cultivated like a garden, and exhibiting in the fields numberless low ledges of limestone rock, beside many of which stand limekilns.

There are certainly evidences of some obscure nonconformability between the limestones of II and the slates of III above them; for, while the strike of the slates is always straight up and down the Valley, that of many groups of these limestone-outcrops is perversely out of line, often crossing the valley at various and sometimes at right angles. But much of this apparent nonconformability is no doubt due to crimpling, although the whole formation is much more nearly horizontal than it has had credit given to it for being; and much of it is a deception, produced by an extraordinarily well-developed system of cleavage-planes. On the whole, the regularity of the bounding mountains, and the symmetry of the Valley itself, are good guarantees against any serious nonconformability.

Before the beginning, and again, after the close of the *limestone* Lower Silurian age, there were depositions of ferruginous mud, causing two slate formations, a lower, No. I, and an upper, No. III. The contact of the limestone and the upper slate, along the central line of the Valley, is marked by a range of iron ore. In a few instances it is abundant and largely excavated for the furnaces of Pennsylvania.

The contact-line of slates just under the limestone No. II, with

the lowest sandy layers of the limestone, gives us likewise a second great belt of iron ore deposits, lying along the foot and part way up the side of the South Mountain. These are the deposits of which Professor Hitchcock speaks in Vermont; and in one of these in Pennsylvania, viz., in the Pond-bank of Mont Alto Furnace, the lignite has been found.

Along the foot of the South Mountain, the feebler brooks, descending from the ravines, sink immediately beneath the surface into a system of underground caverns, which may, without much exaggeration, be called a single cave, extending for a thousand miles, and including in its course chambers, some of which, like Weir's Cave, in Virginia, have become celebrated among the wonders of the world. The stronger brooks unite, and form large streams, or even rivers, which,—like the Lehigh below Allentown, the Yellow Breeches west of the Susquehanna, the Shenandoah south of the Potomac,—flow close over the southern or lower edge of the limestone formation, and therefore close up to the foot of the mountain.

Both this situation of the river drainage on the surface, and this cavern system underneath, tell one story, which cannot be misinterpreted,—the *extra dissolubility of this particular horizon of Lower Silurian rocks.* And that, which we now see going on before our eyes, has, of course, been going on for ages. The fissures which are now being enlarged into caves, and the caves which are fast growing into catacombs, and ramifying into labyrinths of underground darkness, their roofs every now and then falling, so as to produce funnel-shaped sinkholes in the fields and sometimes in the roads, and their floors receiving, through the sinkholes, lots of leaves and fruit, land shells, and perhaps occasionally bones of smaller animals, with every great spring freshet,—all these once had their analogues in time past (vanished now into thin air) beneath some old surface, situated many feet or yards, in fact many fathoms, above the one on which men live to-day.

By this ideal reconstruction of surfaces older and above the present one, we settle most of the difficulties which encounter us in studying the ores of the Great Valley. And I submit, that we obtain, also, a reasonable explanation of the sporadic masses of lignite, two of which are now known to exist in or rather near the iron ore; for it must not be forgotten that the lignite and ore are not in contact at either place. It is only necessary to suppose a sink hole so formed, and so stopped up below, as first to receive and then to retain an accumulation of forest trash, and we have the thing ready

made to our hand. The fact, that it occurred just under, in, or near a great ore deposit, must be regarded as an accident, until we have found enough more lignite deposits connected with ore beds to make some organic or original connection between them supposable. And even then, it must be remembered, that the search is wholly confined to the ore-deposit localities, which of itself would throw doubt upon their connection, even if we had a sufficient number of instances.

I will now give as clear a description as I can of the ore banks of Mont Alto, so as to show, if possible, the actual relationship of the lignite to the ore; granting, in advance, that the description will leave much to be desired.

The brown-hematite ore-deposits of Mont Alto follow the outcrop edges of the slates and sandy limestones which form the southeastern edge of the Valley, as shown in section, Fig. 1, Plate VIII. The ore is in fact nothing but the residue of these beds after decomposition and dissolution, the honeycombed and altered edges of the Silurian slates and sand-limes themselves, after their lime has been washed out of them, and their carbonated and sulphuretted iron has been hydrated and peroxidized. The muddy slates formed the present deposits of small ore with white and red clay. The sandy limestones formed the present harder, silicious, rock-ore belts. The geologist can procure, in the banks, specimens of every stage of this interesting process, from the perfect limestones which refused to disintegrate, and the iron-lime-sandstone with the disintegration and recrystallization begun, to the perfect ball and pot ore of radiated, acicular, crystallized brown-hematite. The great variety in the composition of the original rocks has been the cause of a great diversity in the ores taken from the different openings. But two principal distinctions may be particularly noticed; viz., that the ores which have resulted from the decomposition of the slates are more disposed to the *redshort* side, whereas the ores which have resulted from the decomposition of the limestones are more or less *coldshort;* probably because of the sand in the limestone; it is, in fact, called by the New York geologists the Calciferous Sandrock. The slates, on the contrary, are apt to hold a small percentage of sulphur; or perhaps we should say, are less likely to permit the abundant drainage needful for carrying off the sulphur in the form of a salt. Sometimes in the same deposit there is a mixture of the two varieties, producing a neutral ore. But it is not often that such large exposures of both varieties occur in the same neighborhood, as is the case here.

Taking into view all that we know of these deposits along the

southeast side of the Great Valley, from the Hudson river to Tennessee and Alabama, and adding what we know of similar deposits, produced in a similar way, out of the exposed outcrop edges of the same rocks in the limestone valleys further back towards the Allegheny Mountains (such as Kishicoquillis, Nittany, &c.), and deposits, in the same geological positions in Lancaster and Chester counties, we can divide them with great certainty, as stated above, into two classes, the *slate-crop banks*, and the *sand-lime-crop banks*, the former being always geologically underneath the latter, as represented in Fig. 1.

The cavernous condition of the formation which crosses the Antietam creek at Mont Alto is evinced by the numerous sink holes and ponds lined with clay, and by the absence of small streams, and by the curious topography of the whole slope of the South Mountain, the want of any definite run to the vales, the bowl-shaped aspect of every part of the surface, and the disappearance of the mountain brooks on their way towards the centre of the valley. In other valleys (as e. x. in Sinking Creek Valley, near Altoona) the number and the extent of the caverns astonish and delight the beholder. Where the dip of the rocks is steep there is not the same chance for the formation of caverns; and the depth to which the disintegration of bed, in other words, the formation of ore, can go, is necessarily limited. On the contrary, where the dip is gentle the dissolution is extensive, and the ore abundant.

Within the first half mile there have been excavated several large pits. The bank at present wrought is 2200 feet from the furnace. It is called the Home-bank, and furnishes the principal data for estimating the quantities of ore in the whole belt, Fig. 2.

The excavation is between one and two hundred feet long, and of the shape shown in the figure. Its mouth is a cartway between walls of surface clay or common stripping. Its head is a steep slope of clay, covering ore, from 40 to 50 feet high, behind the top of which rises the mountain side 50 feet higher, to a gently sloping terrace, as shown section, Fig. 3.

As there are but from 5 to 10 feet of stripping, and the ore in fact sometimes comes within that distance of the surface, the plan shows at a glance the immense extent of the ore ground. The new workings are ordinary gangways, timbered and lagged where needful, with cross galleries driven to the right and left, in an irregular manner, but so as to leave 50 foot pillars of ore between them, and not kept carefully upon a level. In fact, one of the gangways to the

right rises so fast as to overrun the timbers of the old tunnel (See Fig. 2) which is driven into the face of the quarry at a level 20 or 30 feet higher than c. Another gallery has a shaft 30 feet deep at its end. The whole mine is in fact nothing but an extensive shaft exploration, leaving the mass of the ore untouched. We have, therefore, data in sight for the following calculation:

Quantity of Ore in the Mine, in Sight.

Galleries one way, 200 + feet = 70 yards, Galleries the other way, 150 feet = 50 yards, Average height above tunnel, 50 + feet = 17 yards,	say 60,000 cubic yards.
Add length of quarry, 150 + 150 feet = 100 yards, Take same breadth as above (200) = 70 yards, Depth of shaft in quarry, (70 +) = 25 yards,	say 175,000 cubic yards.
To which add for quarry slopes, &c.,	say 15,000 cubic yards.
Total in sight of the Home-bank,	say 250,000 cubic yards.

This does not take into account the existence of ore to a greater depth than the bottom of the shaft, 70 feet, where, as the miners assert, they stopped in solid ore; and there is no reason to doubt the fact, seeing 1, that the 30-foot shaft, at the inner end of the side gallery, left off in ore, and the dip would carry it far below the bottom of the 70-foot shaft; and, 2, the bottom of the 70-foot shaft is still 70 feet above the creek at the furnace, and therefore within the limits of underground drainage and decomposition. It is also left out of sight, in the above calculation, that the ore passes outward and downward from the quarry in the direction of x, (Fig. 3), all of which must be added to the sum total above.

Thus, a surface section of the ore belt 50 yards long represents ore beneath it to the extent of, say 250,000 cubic yards.

The mining done in past years from this bank half way to the furnace, and the exhibitions of ore at the surface at the furnace, warrant us in using the above calculation for that distance, viz., 2200 feet, or say 700 yards, = 3,500,000 cubic yards of ore in the ground.

Openings made, also, at intervals, beyond the Home-bank, to a distance of a mile and a quarter from the furnace, will, on the above calculation, increase this quantity to 11,000,000 cubic yards of ore in the ground. There is no reason for doubting that the ore belt continues equally rich to a greater distance northward, along the face of the mountain, past the White Rock Gap, and towards the Conecocheague, at Caledonia Iron Works. But as the surface exposures can never be implicitly relied on, and as the quantity of ore depends more upon the local depth of drainage and decomposition than upon any

other consideration, it is hazardous to extend the calculation further. Towards Quincy and Waynesborough, no good openings have been made in that part of the belt, although the surface is covered with blocks of ore, and the wash ore is seen in the roads. It is probable that as large an amount can be obtained south of Mont Alto Furnace as north of it.

The ore in the ground consists of ball ore and wash ore, with lumps, plates, and streaks of clay. The clay is thrown out where it is in sufficiently large lumps, and the rest of it is washed off. There remains a good deal of clay in the balls, which are irregular globes of hematite, oftentimes hollow, and lined with beautiful acicular crystals, standing apart like the bristles of a brush, but set at an angle with the inside face of the shell.

The ore when washed is about a 50 per cent. ore, the books showing that 4600 pounds of washed ore made a (long) ton of iron.

Professor Booth's analysis gave:

Sesquioxide of iron,	75.00
Alumina,	1.00
Silica,	16.00
Water,	8.00

(omitting decimals) with a trace of lime remaining. The iron has always been inclined to coldshort, on account of the silica, and has usually been mixed with ore from the Pond-banks (to be described below), when it makes a very tough iron. Tested in Washington, with three other varieties of iron, it stood as follows:

Tredegar	iron	sustained	32,000	pounds.
Ulster	"	"	32,000	"
Glendon	"	"	34,000	"
Mt. Alto	"	"	34,000	"

(decimals omitted), the test bar being round, and its section equal to a square of .75 inch.

To get the percentage of lump clay, I calculated the contents of the tip-heap in front of the old tunnel, b, out of which it was taken, and from which were also taken the proceeds of two years' mining for the furnace, say 4000 tons of ore. The tip-heap contained about 100 cubic yards of clay refuse.

I also saw washed 13 barrows of "wash ore," containing no lump clay, and saw that they yielded 11½ barrows of washed ore ready for the roasting pile; = 90 per cent.

The proportion of *lump clay* in this tunnel to *unwashed ore* must have been, say from 5 to 10 per cent, by weight.

The proportion of clay to ore near the surface is greater than it is further down, probably because the drainage from the surface into the already made ore has charged all its vacancies. But whatever be the explanation, the ore-mass becomes denser and richer continually as one descends in the quarry, and the deepest shafts sunk have left off in very hard, pure ore. In the limestone deposits of pipe ore, the lower limit or extreme bottom plane of dissolution is characterized by an accumulation of very pure and beautifully crystallized hydrated peroxide of iron; and all these deposits are, therefore, richest at the bottom. A mass of rock ore lies thus behind the present works, and below them; or, in other words, forming the "foot-wall" or "underlay" to the deposit. This rock or hard ore is struck in the galleries, and is not worked, because it requires blasting; whereas, all the rest of the mass can be picked and shovelled. In the future open quarries, this mass of ore will form the richest part of the work. It is merely a more compact form of brown hematite, perhaps a little more silicious than the rest. The terrace above the works shows much surface ore, and on this terrace come up the slates which hold the Pond-bank ore, hereafter to be described.

Again, outside, or above, or to the west of, the Home-bank belt (B, of Fig. 2), there is a third belt (C), the outcrop of which is shown by a sharp small ridge in a field, covered with blocks of hard ore from one to two feet in diameter. The whole surface of this sloping field, from the little ridge downwards, for a hundred yards, is strewed with this ore, many tons of which have been collected and smelted in the furnace. It is probably in connection with this ore belt that we find an outcrop of almost unchanged blue carbonate of iron and lime, several feet thick, mottled with groups of crystals of white calc spar, and evidently, in parts, changing into honeycomb brown-hematite ore. It lies with a dip of 20° towards the west.

There are evidences of other belts further west still; and a limestone quarry, used for fluxing the furnace, shows a 45° reverse dip (towards the east), by which we know that there is a basin, running along the bottom of the slope of the mountain, and an anticlinal axis west of it, bringing up the ore-bearing formations towards, and perhaps to, the surface; which is sufficient to account for the ore belts just mentioned.

This synclinal axis is the same which runs in between the Little

Mountain and the Main Mountain at the Pond-banks (or rather at the English openings; see the map, Plate IX). The anticlinal axis is no doubt that of the Little Mountain itself, which brings up the slates on the back of the Pottsdam sandstone, and thus produces the grand exhibitions of ore all around it, as shown in Fig. 4.

The Pond-banks and Caledonia-bank, and the English diggings, are several openings of greater or less size in the upturned belt of slates surrounding the Little Mountain, which rises as an isolated ridge, one or two miles long, from the floor of the valley. The English diggings are behind it, the Caledonia-bank before it, and the Pond-banks at its south end, in the plain. The ore mass in the Caledonia-bank dips 5° towards the mountain, but must certainly rise again upon its flank. The English ore evidently dips 10°—15° away from the mountain. The difficulty of estimating the quantity of ore on this ground is very great, on account of the enormous covering of red earth upon it in places. The shape of this deep excavation is that of a crescent, with nearly vertical sides, and an irregular bottom.* Its whole length is about three hundred yards, and its depth to the general floor is from 60 to 80 feet. The ore appears within 10 to 20 feet of the surface, at some points, and at others not for 30 or 40 feet down. Mountains of stripping stand beside it to the west, above where the body of the ore turns over a small anticlinal, and buries itself westward beneath undecomposed limestone. The depth of the ore is still unknown. Shafts from 60 to 110 feet have been sunk in it at the sides and in the bottom of the present excavation. The top of the ore stratum at the extreme north end of the quarry is exactly on a level with the edge of the upper Pond-bank, which is only 5 or 10 feet above the top of its own ore, into which the mining has descended 30 to 40 feet. The lower Pond-bank is on a slightly higher level.

The fact is, therefore, that all these three excavations, separated by only one or two hundred yards of interval from each other, and extending in a line about one thousand yards, are sunk in one deposit of ore; or, to speak more correctly, in the broad overlapping margin of the ore-bearing slate deposit, which sweeps round the south end of the Little Mountain in a nearly horizontal and partly basin-shaped posture.

In the bottom of these excavations the ore is reported as uniformly well compacted. In the upper end (north end) of the Caledonia-

* The sketch Fig. 8, Plate X, was made from the head of the road.

bank at a depth of say 60 feet from the surface, I saw the top of a body of ore which was as solid as a mass of cellular brown-hematite ore could be. In other parts the ore is distributed through clay. The whole is worked with pick and shovel. The large tip-heaps at Caledonia-bank show the quantity of stripping done, rather than the amount of clay mixed with the ore, and the small size of the tip-heaps about the two Pond-banks speak well for a large percentage of ore in proportion to clay.

Taking, then, the length and the width of the three banks for a basis of calculation, and giving only 50 feet as the average depth of the ore, and deducting 50 per cent. for clay (which is very large), we see: 1000 yds. $\times$ 100 yds. $\times$ 17 yds. $\div 2 = 850{,}000$ cubic yards of ore in the ground, from which the extracted ore has been deducted. Starting with this amount of ore "in sight," and applying the calculation to the ore descending on the west, ascending again on the east, outspreading to the south, and filling the little valley behind the Little Mountain, past the English diggings, we get many millions of tons in addition, and under precisely the same conditions, viz. with a variable covering of soil, clay, and loam, say from six to twenty feet thick; nearly horizontal; compact towards the bottom and loaded with clay in places; the ore all in small pots, and shards, and gravel-like pieces; yielding about fifty per cent. of metal, and showing a neutral character, making excellent iron. The amount of clay in these banks is highly in excess of the amount at the Home-banks. On the other hand the amount of silica is less.

The Lower Pond-bank is said to have mined from five to ten thousand tons of ore, beginning within ten feet below the surface, and descending at least thirty feet, without bottom.

The Upper Pond-bank is said to have a depth of forty-three feet in ore, the ore coming to within ten feet of the surface. From the bottom of the original central shaft they drove a tunnel out to daylight, and used it afterwards for hauling out the ore.

The English diggings, on the back of the Little Mountain, are only a trench, fifty feet wide by one hundred and fifty long, and from five to twenty-five feet deep, cut slanting up the side of the mountain (or hill, as it really is not 200 feet high), and showing a white clay covering, massive, eight feet thick, dipping 20° to the eastward. The ore, which is under it, cannot now be seen, because of the condition of the pit; but a set of fresh trial pits, outside of the main pit, show the ore in good condition within five feet of the soil.

A branch railroad from Scotland Station, up the valley of the

Conecocheague, *seven miles*, to the Caledonia and Pond-banks, and thence forward along the ore belt, *two miles*, to the Home-bank, and *one mile* further to Mont Alto Furnace, making ten miles in all, is about to be constructed. The route follows a wide and shallow meadow valley, with a rise (by barometer) of 20 feet in the first four miles; 90 feet in the next three miles, to the first ore beds; and 230 feet for the next two miles, to the Home-bank opening.

The water of the creek at the furnace is 140 feet below the Home-bank, and 200 feet above railroad grade at Scotland Station (measured by one of Becker & Sons' Aneroid Barometers).

It is within a few hundred feet of one of the Pond-banks that the shaft has been sunk, which penetrated the lignite layers; and it will be noticed, that their horizontality is in agreement, 1st, with the horizontality of all the Silurian measures which sweep round the flat south end of the Little Mountain anticlinal; 2dly, with the horizontality of the ore deposits; and, 3dly, with the general plane surface of the locality. There is no good objection to considering the lignite beds a local deposit of late date, made in a shallow pond, produced either by erosion, or by settling, caused by cavern-solution close underneath, and puddled with the ore-clay so as to hold water and maintain a fresh-water vegetation, with which the forest leaves and trees, incessantly discharged by freshets, would be intermingled. This may have happened at any age after the uplift of the palæozoic system and the subsequent production of the present surface, except so much time as may be represented by the forty feet of sand, &c. lying upon the lignite. There is, therefore, to choose from, the whole interval embraced by the Permian, Jurassic, Cretaceous, and Tertiary areas.

To determine this more nearly, there must first be a determination of the relation existing between the surface of the Palæozoic region and the surface of the Permiano-Jurassic region, commonly separated from each other by the mountain barrier of the Highland-South-Mountain-Blue-Ridge range, but touching each other along the remarkable gap in that range, between the Schuylkill and Susquehanna rivers, and represented on the colored map, plate XI. The present relation of the two surfaces to each other, is shown in Fig. 10, plate X, and a selection from some of their supposed relationships in past times is made in Fig. 11. The so-called New Red Estuary rocks are seen in these sections dipping uniformly northwestward, at angles from 20° to 30°. Their highest stratum, the breccia called Potomac Marble, is sometimes a conglomerate of well-rolled pebbles, in which I have often recognized, not only fragments of the Lower

Silurian limestones and slates of II and III; but quartz pebbles from the Middle Silurian (Llandovery) sandstone of IV, or the not much more distant outcrops of the Upper Devonian and Carboniferous conglomerates of X and XII.

The New Red is seen dipping northward against a country which is lower than its own. The question is not one of a fault to produce this dip: 1. Because a fault which should throw the New Red *down*, must necessarily leave the Silurian dominating it from an elevation; 2. Because the dip exists everywhere, along the estuary for 500 miles, where its northern coast is a mountain anticlinal of Azoic, without trace of fault; 3. Because the north edge of the New Red, at the place of section, is scalloped in such a form as no fault of any magnitude could produce; 4. Because the exposures are good and numerous, and yet there is nothing to show the existence of a fault, upon the ground.

The New Red is seen in the section dipping northward against or toward a country, the surface of which is three hundred feet lower than its own. There is no evidence of a wide extension of New Red over that lower surface in the New Red age. On the contrary, not a hillock or gravel patch of New Red is to be found throughout the whole Palæozoic country to the north or west of this, its present absurdly constructed overhanging and outdipping margin. How is this to be accounted for?

There must have been some barrier to the New Red waters between the Schuylkill and the Susquehanna, to correspond with the barrier which we see everywhere else between the Hudson and the James. Otherwise the New Red waters would have overflowed, by *at least* three hundred feet, the Silurian Valley in its rear, and penetrated to valleys still further back by means of the principal gaps in the Kittatinny Mountains through which the Schuylkill, the Swatara, and the Susquehanna rivers flow. What was this barrier ?

I think none can be suggested but one composed of the *originally much more elevated surface of the Silurian Valley itself.* Carry up the whole mean level of the Palæozoic area—the valley beds up to the present height of the mountains, and the mountain crests to a proportionately greater altitude, the gaps to correspond with both, and the anticlinal and synclinal structure to determine the face of the surface at any given stage of the process,—and we have the required barrier to the estuary of the New Red; the explanation of its top Conglomerate; a good reason why there are no New Red traces

back of the South Mountains; and a closer date for the Lignite of Mont Alto.

In Fig. 11, plate X, where such a reconstruction of an ancient surface of the Great Valley is attempted, there is noticeable, 1. How vast an amount of Palæozoic rock-substance has been swept away; and, yet, that amount represents only the waste of the four lower Palæozoic formations; superposed upon these at a still older date, eight others, including the Coal Measures, must have formed their surfaces; supposing no cataclysm. 2. How fine a chance was given for collecting towards the present surface the ferruginous elements of the slowly decomposing and cavernous-becoming limestone layers; and 3. How the erosion must have acted, for some reason or other, more upon the Palæozoic surface outside, than upon the Palæozoic surface inside the limits of the New Red; the reason probably being, simply, this: that the latter was under the New Red waters, and was being covered up, while the other was being eroded; but the erosion had not yet brought the valley surface down to the New Red water-level, when the uplift of the New Red took place. After which, the two erosions went on with different velocities proportional to the different solubilities, &c., of the Silurian limestone, and of the New Red sandstone, formations.

As for the lignite, therefore, it must have been subsequent to the erosion of the New Red, that is, certainly not older than the Cretaceous lignites of the United States; and when we consider the immense lapse of time needful for carrying the Silurian Valley surface from a level with the tops of the New Red Hills, down to a level with their feet, we may well believe that the precise condition of the ore deposits as we see it, while it commenced before New Red times, was not perfected until the latest tertiary age, and, therefore, this last must be the age of the lignite—apart from all consideration of fossils.

[Captain Geo. B. Wiestling, Superintendent at Mont Alto, writes under date of Jan. 20, 1865, as follows:

"Our pit No. 1, primitive iron ore (Pond-bank), lies at the southwest foot of the 'Little Mountain,' close by the township road leading from Greenwood, on the Baltimore turnpike, to Altodale, near our works. About seven hundred (700) feet south of this pit, we have another larger pit, No. 2. These are about three-fourths of a mile west of a spur (Mont Alto) of the South Mountain. The neighborhood is dotted with a number of ponds, from which it derives its name, 'Pond-bank.' In order to drain the water from and

beneath both these pits, we located and sank a shaft between them and nearer the larger pit. Although our judgment would have dictated a locality a little more eastward, to have struck the bed of ore, yet we selected this as more favorable ground for sinking.

"At a depth of five feet from the surface, we came upon the beautiful white clay which lies immediately upon the ore, and is more or less mixed with it.

"At ten feet from the surface we penetrated through the white clay and met a clear, sharp, light colored sand, which continued for about five feet.

"Then we found yellow clay mixed with sand, and spotted with red clay (pigment). This varied but little until we attained a depth of forty (40) feet from the surface, where, at a distinct, decided line, almost horizontal, dipping, if at all, a little south, we encountered a close-grained, tough, black clay, with small particles, as large as a grain of wheat up to a grain of oats, resembling small pieces of charcoal, intermingled with it. This proved only one foot thick; and then, at a depth of forty-one (41) feet from the surface, we came upon the *lignite.*

"After penetrating this four (4) feet, a layer, one foot thick, of a tough, gray, sandy substance, intervened; after which we met a lower stratum of the lignite, apparently growing more solid as we descended.

"Through this we continued to sink, for eighteen feet further, where about one foot of sand covered a beautiful variegated clay, pearl and white body, with crimson and purple streaks through it. At two feet deeper, the southwest corner of the shaft showed pure red, and the northeast corner pure white clay.

"Thus far, then, we had sunk sixty-seven (67) feet from the surface, and had developed two strata of lignite, respectively four (4) feet and eighteen (18) feet thick.

"This depth (67 feet) was more than necessary for our purposes in sinking the shaft, and we commenced a drift or adit, three feet above the bottom of the shaft, in the lignite, in the direction of the layer, pit No. 2 (south). This drift we have driven, to this date, forty-eight (48) feet in the lignite; but yesterday the ground showed evidences of a change to light-colored clay. We have concluded to return to the shaft, and from its bottom sink a smaller pit still deeper, for purposes of observation; a small contribution to science The results I will advise you of as we progress, with pleasure.

"The lignite, when excavated, was solid, rang and glistened like anthracite. Exposure to the air disintegrated it to a certain extent, and impaired its lustre. It burns freely, with a bright flame and intense heat, and proves excellent for generating steam. It cokes beautifully.

"When drying pieces of it (for experiment) on the stove, a considerable quantity of oil fried out, and the empyreumatic odor was very decided. This circumstance, in connection with the fact of a heavy, greasy coating on our springs and streams (heretofore credited to the iron ore), causes considerable speculation as to the existence of petroleum at no great depth.

"In the field lying between the 'Little Mountain' and South Mountain, east of the English-bank, we have sunk a number of test pits. In all but one, we have found ore near the surface. In this exception, located about two hundred feet east of the English-bank, at a depth of fifteen (15) feet, we encountered a black clay, similar to that which immediately overlaid the lignite at the Pond-bank.

"A number of circumstances combined to prevent our sinking the pit any deeper at the time, though we intend developing what lies beneath, in the early spring."]

Mr. Foulke inquired whether or not any of the members present had collected such evidence in relation to deposits of iron, as would throw new light on the origin of such beds.

Mr. Foulke referred to the discovery of the part which infusoria had taken in the formation of silicious rocks, and remarked upon the contributions of the United States Coast Survey; and said, that the fact of assimilation of iron by minute marine animals, might suggest an analogy with Ehrenberg's microscopic results in the origin of beds of iron.

Mr. Lesley remarked upon the appearance of encrinites in strata of carbonate of iron, as interesting exemplifications of the metamorphosis of encrinitic limestone deposits to iron ore beds among the coal measures.

Mr. Foulke recurred to the distinction between the example of carbonate of iron and that which he had presented, viz.: the formation of ore-beds in a manner analogous with those of Ehrenberg's silicious rocks.

Mr. Osborne, present by invitation, exhibited a port-folio of lithographic plates, and explained his process of copying by Photo-lithography. Mr. Osborne said:

This method of combining photography with lithography is not new; it is a tried and tested process, which for upwards of five years, has been actively employed by the government of the British Colony Victoria, for the production of maps. The invention dates from the 19th of August, 1859, and the first official map was produced by it on the 3d of September following; since which time several thousand different original maps have been photo-lithographed by its means, and sold to the public. The saving, both in time and money, which its introduction has effected, is very great; and the government of the colony has erected, according to my suggestion and plan, a substantial office consisting of several rooms, exclusively for the prosecution of this method of reproduction. In 1861, the Victorian Parliament acknowledged my services, and the estimation in which they held the process, by voting me unanimously the sum of £1000.

The general history of photo-lithography, and the details of the various processes which have been put forward from time to time, is a subject too extended for me to discuss on the present occasion; I shall confine myself therefore, to a description of my own solution of the difficulty, the superiority of which, for certain kinds of work at least, I believe now to be undisputed.

Before proceeding to details it may be well to state, that the process is designed and fitted for the reproduction of existing originals only, such as maps and plans, engravings, pen-and-ink drawings, MS. and printed documents, &c., and not for producing portraits or views directly from nature. The problem to be solved may be defined, more accurately, as follows: From a given original existing as a black and white drawing or engraving, to produce by the chemical agency of light, a fac-simile on stone, identical in character with an ordinary lithographic drawing, which has been fitted for the printer.

The first step in the process is the production of a negative, which shall bear the desired relation to the original in size. This is done by placing the latter upon an upright plan-board, and the camera opposite to it, taking care that the plan-board and the ground-glass slide of the instrument are perfectly parallel, and that the distance between them is such as to give a copy of the desired dimensions. The negative picture is then taken in the ordinary way on collodion, but with numerous precautions, so as to secure the best possible result.

Having proceeded thus far, it is necessary to prepare the sensitive surface upon which the positive print from this negative is to be made. All the processes of which anything was known or published up to my time, were based upon the idea that the surface of the stone should be made sensitive to the action of light, and that the photographic picture formed thereon should possess the necessary and peculiar lithographic properties. I deviated from my predecessors in this respect, and struck out a new course, which at once gave superior results. This consisted in sensitizing a sheet of paper in such a way as to make it fulfil similar conditions; and having produced upon it a photograph in lithographic ink adapted for the purpose, the same is transferred to stone by a well-known lithographic operation, and printed in the ordinary way.

To effect this object, a sheet of paper of the best quality is prepared with a solution of gelatine and bichromate of potash in water, to which a quantity of albumen has been added. This mixture is poured into a long narrow trough, and one side of the paper is covered with it, by drawing a sheet over the fluid in the trough, while an assistant presses it into contact with the same by means of a piece of wood of suitable form.

The paper thus coated is carefully dried in the dark, and upon it a positive print from the negative above mentioned is printed by light in the manner practised by photographers. The result is that a brown picture makes its appearance upon the clear bright yellow of the paper, identical in every respect with the original which was copied, unless perhaps a reduction or enlargement in size may have been decided on. It is not however the change in color which makes this picture valuable for photo-lithographic purposes, but rather the alteration in the chemical and physical properties of the organic substances, which form the superficial coating upon the sensitive paper, the nature of which will be understood when the following operations are described. These are technically known as "blacking," "swimming," and "washing off." Blacking an exposed positive has for its object the distribution of an even coating of lithographic transfer ink over its surface. Such an ink is essentially composed of greasy or resinous substances fused together, and blackened with lampblack. For our present purpose it is distributed with the printing roller over the surface of a stone in the press, and upon it the exposed positive print is laid, with the photographic picture downwards, and in contact with the ink. After passing both stone and paper through the press, and separating them, the latter will be found to have brought away

with it an even coating of the lithographic ink, hiding almost totally the photographic delineation from view. The swimming, or as it is also more properly called, "coagulation," is the next step; it is accomplished by letting the blackened print float upon the surface of boiling water, with its uncoated side downwards. The chief result sought to be secured by this operation is the coagulation of the albumen contained in the film. This takes place, due to the action of the moisture and heat together; and in addition to it another advantage is gained by the percolation of the water through the paper, namely, the softening and gelatinization of the gelatine contained in the coating of organic matter under the ink. This change extends only to such portions of the sensitive surface as were protected from the action of light by the negative; those which form the picture suffer no further alteration while the print is swimming, due to the solvent action of water; they do not soften or swell, and demonstrate this fact by remaining depressed, in relation to the other parts of the blackened surface, which rise very perceptibly around them.

After sufficient soaking, we have to remove from this print the superfluous ink which is upon it, our object being to retain that portion only which goes to form the picture. This is effected by placing the wet sheet upon a smooth surface, and applying a moderate amount of friction to it by means of a wet sponge, or similar substance. Gradually the ink leaves those portions of the blackened print which represent the white parts of the original; but the exposed or positive portions retain it with great tenacity, owing to the chemical alteration which the light has effected in them. Eventually we find ourselves possessed of a copy of the original in lithographic ink, which is washed in abundance of water, and dried.

The ink upon the print, the preparation of which has been just described, is transferred to stone by a process more or less thoroughly understood by ordinary lithographers, occurring as it does not unfrequently in the routine of their business. It consists in laying the print, inverted, upon a clean and smooth lithographic stone, which has been slightly warmed, and passing it through the press. The consequence is, that the greasy lithographic ink passes over to the stone, and forms there a chemical picture which is reversed, and from which, after it has been properly "etched" or "prepared," impressions can be taken in the press.

The coagulated albumen, upon which some stress has been laid, plays an important part during this operation of transferring; for, owing to its insoluble nature, no amount of washing can remove it

from the surface of the paper; and after the print is washed off and dried, the inky picture is found to rest, as it were, upon a sheet of albumenized paper. This is damped slightly before laying it upon the stone, and, when the heavy pressure of the press is brought to bear upon it, the albumen shows an amount of adhesiveness sufficient to make it stick fast, and prevent any shift, or doubling of the lines, until the stone and print have been carried through the press as often as the operator thinks necessary.

The latest application which has been made of this process, is one to which I attach much importance; I refer to the illustration of a Prussian Government work, descriptive of the expedition which that state sent a few years ago to Japan, China, and Siam. I am happy in being able to lay the plates belonging to the first part of this work before the members of your Society. They consist of twelve small views and six large ones, besides two maps, and are reproductions of pen-and-ink drawings, made by the landscape painter, Mr. A. Berg, who was sent with the expedition. Two of the larger plates are printed in colors, in imitation of water-color drawing, a combination of chromo- with photo-lithography, which is here made for the first time. On the worth of a process of this kind, whereby every touch and every feeling which the artist puts into the creations of his genius, is reproduced in permanent printing-ink, or by means of which rare and costly engravings can be given to the public at a nominal cost, I do not require to dilate. Mr. Berg, whose connection with the Japanese work naturally makes him a severe critic, has expressed his opinion to me in a letter which I value very highly, and I feel that I cannot conclude my remarks better than by quoting the portion of his communication which bears upon this subject. He says:

"The President of the Royal Commission, appointed to superintend the publication of the East-Asiatic Travels, has requested me to express to you his grateful acknowledgments of your great services and disinterested exertions in this work. It gives me the greatest pleasure to be enabled to make this communication to you; and I avail myself of the opportunity to express to you also, my own sincere thanks for your assistance in this work. You have solved the most difficult problems in this field,—problems, the solution of which I myself despaired of, until the successful result was placed before my eyes. The question, whether pen-and-ink drawings can be multiplied by photo-lithography, and thus made valuable to the artist, is determined by this work."

Mr. Osborne exhibited a portfolio of reproductions of engravings, pen-and-ink drawings, maps, &c., of great excellence, and some of them of rare beauty, fully justifying, in the opinion of the members present, his views of the merits and utility of the process.

President Smith exhibited a piece of lignite from the Dutch Gap Canal, just excavated by the troops of General Butler, to facilitate the operations carried on against Richmond.

The stated business of the meeting being called for, it was, on motion of Prof. Cresson, resolved, that the subject of the claim signed "Torricelli" was worthy of the Magellanic Premium.

The members were then required by the terms of the Fund to declare whether they had considered the subject, so as to entitle them to vote; whereupon the members so making declaration voted, by ballot. The ballot-boxes were then scrutinized by the presiding officer, who announced that the vote was unanimous, and in favor of bestowing the premium upon the claimant.

The sealed package was then opened by the President, and the name of Mr. Pliny Earle Chase was read.

PHILADELPHIA, October 1, 1864.

DR. GEORGE B. WOOD,

President of the American Philosophical Society.

DEAR SIR: I offer, for a Magellanic Premium, the discovery of certain new relations between the solar- and lunar-diurnal variations of magnetic force and of barometric pressure.

The experiments upon mechanical polarity, which were exhibited to the Philosophical Society at its meeting of April 1, 1864, and the series of communications to the Philosophical and Royal Societies, of which those experiments formed a part, have shown that the simple aërial and aethereal currents which are produced by the combination of solar and lunar action with rotation, are sufficient to polarize the atmosphere, and through its specific magnetism to impart a directive polar energy to a magnetized needle.

Since the principal agency of the sun in producing currents and barometric fluctuations appears to reside in the heat of its rays, and that of the moon in its differential or tidal attraction, it seems very probable that the ratio of the barometric to the magnetic disturbance of each luminary may be some function of the relative barometrical and tidal effects of the two bodies. This hypothesis is confirmed by the fact that the lunar-diurnal variations, both of the magnet and of the barometer, exhibit two high and two low daily tides, while the solar-diurnal magnetic variation, like the temperature-tide of the barometer, has only one maximum and one minimum in twenty-four hours.

Let $A =$ the tidal-current variation of equilibrium.

$B =$ the diurnal barometric variation.

$M =$ the diurnal magnetic variation.

Let the solar elements be distinguished by A', B', M'; the lunar by A'', B'', M''.

If the modern physical hypotheses are correct, and the forces that produce A, B, and M are all forms of motion, it is probable that some simple relationship may exist between them. In endeavoring to ascertain that relationship, we readily discover that

$$A' < A''$$
$$B' < M'$$
$$B' > B''$$
$$B'' > M''$$

These inequalities, together with the fact that the solar currents are developed in air that is disturbed by the greater attractive energy of the moon, and the lunar currents in air that is disturbed by the more powerful barometric action of the sun, suggest the supposition that B may be a mean proportional between A and M, and that we may therefore have the following equivalent proportions:

$$B' : B'' :: \sqrt{A'\ M'} : \sqrt{A''\ M''}$$
$$A' : A'' :: B'^2\ M'' : B''^2\ M'$$
$$M' : M'' :: B'^2\ A'' : B''^2\ A'$$

From the same considerations, we may readily infer that

$$\frac{B'}{M'} = \frac{A'}{A''} \qquad (1)$$
$$\frac{B''}{M''} = \frac{B'}{B''} \qquad (2)$$

and that, $\therefore$, B'' is a mean proportional between B' and M''.

According to Maj.-Gen. Sabine's tables (St. Helena Obs., vol. ii, p. lxi), there is a solar maximum, measured in parts of the total force,

of +.00095 at noon, and a solar minimum of—.00045 at 11 P. M.,

$$\therefore \quad M' = .0014 \quad (3)$$

The lunar tide is so modified by rotation, that its true value can perhaps be best ascertained by adding the tides at equal distances from the lunar meridian (op. citat., p. lxii), and taking their average.

LUNAR-DIURNAL MAGNETIC VARIATION, IN MILLIONTHS OF THE TOTAL FORCE.

	0 h.	1 h.	2 h.	3 h.	4 h.	5 h.	6 h.	7 h.	8 h.	9 h.	10 h.	11 h.	12 h
Before Lunar M.,	+5	—1	+4	—2	—5	—5	—6	—3	—2	—1	+14	+15	+16
After " "	+5	—1	—5	—6	—7	—6	+1	+1	—2	+18	+25	+22	+16
MEAN TIDE, . .	+5	—1	—.5	—4	—6	—5.5	—2.5	—1	—2	+ 8.5	+19.5	+18.5	+16

We thus obtain an average low tide of —.000006 at 4 h., and a high tide of +.0000195 at 10 h., which gives

$$M'' = .0000255 \quad (4)$$

The values of B, as deduced from the tables presented at the meeting of July 17, are

$$B' = .016 \text{ in.} \quad (5)$$

$$B'' = .00365 \text{ in.} \quad (6)$$

Dividing by 28.2821, the mean height of the barometer, in order to obtain results in terms of the total barometric pressure, we have

$$B' = .00056573 \quad (7)$$

$$B'' = .0001291 \quad (8)$$

The relative values of A′ and A″ have never been precisely determined. Probably the latest and most correct estimate is the one given in the New American Cyclopedia, Article "Tides," according to which, if

$$KA' = 1 \quad (9)$$

$$KA'' = 2.55 \quad (10)$$

Of the homologous quantities contained in (1) (2), it is fairly presumable that those of the greatest magnitude (B′, M′) have been most precisely estimated. Assuming their accuracy, we have:

1. If (8) be supposed correct,

$$M'' = .00002944 \quad (11)$$

$$\frac{A'}{A''} = \frac{1}{2.475} \quad (12)$$

2. If (4) be supposed correct,

$$B'' = .00012 \quad (13)$$

$$\frac{A'}{A''} = \frac{1}{2.475} \quad (14)$$

3. If M' and B'' are required, (4), (9), (10), being supposed correct,

$$M' = .00144 \qquad (15)$$

and the value of B'' is the same as in (13).

Other hypotheses might be made, but these are sufficient for illustration.

Even the widest discrepancy between theory and observation is much less than might have been reasonably anticipated in measurements of such extreme delicacy, and far within the limits of probable error, as will be seen by the following synopsis:

	KA′	KA″	B′	B″	M′	M″
Observed,	1	2.55	.00057	.00013	.0014	.0000255
Theoretical, 1	1	2.475	.00057	.00013	.0014	.0000294
Theoretical, 2	1	2.475	.00057	.00012	.0014	.0000255
Theoretical, 3	1	2.55	.00057	.00012	.00144	.0000255

From the hypothetical formula $B = \sqrt{A\ M}$ we deduce the following values:

	Observ.	Theor. 1.	Theor. 2.	Theor. 3.
K	4374	4374	4374	4499
A′	.000229	.000229	.000229	.000222
A″	.000653	.000566	.000565	.000565

In regard to the first theoretical value of M'', it may be observed that it is very nearly equivalent to the mean between .000032, the extreme excursion of the lunar tide, and .0000255, the mean tide.

"TORRICELLI."

Mr. Chase made some remarks, in explanation of the subject of the premium.

In the fifth century before the Christian era, Leucippus and his disciple Democritus taught that heat is the soul of the world, the principle of life and intelligence, and that space is an infinite plenum, pervaded by material atoms too minute to be perceptible to the senses, which, by their constant motions, unions, and separations, form the beginnings and ends of things. In this theory, which is said to have been borrowed from the priests of Isis and Osiris, we may trace the origin of the modern belief in a universal kinetic æther, and of the attempts to resolve all forces into "modes of motion," which were practically inaugurated by our own countryman, Benjamin Thompson, Count Rumford, and which have been so successfully prosecuted by Carnot, Seguin, Mayer, Colding, Joule, Grove, and their collaborators.

The mutual convertibility of Light, Heat, Electricity, Magnetism, Chemical Affinity, and Vital Energy, may be now regarded as one of the most probable physical hypotheses. Faraday has endeavored also to connect gravitation and magnetism or electric action by experimental results, but in vain. Still, the conviction of such a connection is almost irresistible, and various physicists have given us incidental pointings in that direction. Ampère discovered the magnetic effect of electric currents circulating around iron bars; Arago, whose experiments were repeated and extended by Babbage, Herschel, Barlow, Christie, and others, showed that simple rotation produces magnetic disturbances which are governed by fixed laws; the distribution of induced magnetism in masses of iron, as determined by Barlow and Lecount, is the same as would follow from the relative centrifugal motions of different portions of the earth, provided the magnetic axis corresponded with the axis of rotation;* Hansteen suspected, and Sabine practically demonstrated, the influence of the sun upon terrestrial magnetism; Secchi ascertained that "the diurnal excursion of the needle is the sum of two distinct excursions, of which the first depends solely on the horary angle, and the second depends, besides, on the sun's declination,"† and that "all the phenomena hitherto known of the diurnal magnetic variations may be explained by supposing that the sun acts upon the earth as a very powerful magnet at a great distance."‡

This hypothesis has been objected to on the ground that it is difficult to understand how any conceivable intensity of solar magnetism, by its simple induction, could produce so great a disturbance as is daily observed. Therefore it will probably follow the fate of the earlier ones, which attributed terrestrial magnetism to one or more powerful magnets lying nearly in the line of the earth's axis, while Barlow's idea that the magnetism is superficial and in some manner induced,§ will still remain in the ascendant. Secchi's conclusions are, however, none the less interesting, and from the fact that magnetism is, like gravity, a central force, varying inversely as the square of the distance, they lend encouragement to those who are endeavoring to find new evidences of the unity of force.

My own experiments and researches have led me to the belief that all magnetism is a simple reaction against a force which disturbs

* This fact was first announced by me, at the Society's meeting, April 15, 1864. See *ante*, p. 367.

† Phil. Mag. [4] 8, 396. ‡ Ibid. 9, 452. § Phil. Trans., 1831.

molecular equilibrium, that the numerical equivalent of the magnetic force is therefore equal and opposite to that of the disturbing force, ($\pm M = \mp D$), and that all the phenomena of terrestrial magnetism result from tidal and thermal changes in terrestrial gravitation.

Sullivan* and Reinsch† have pointed out the effect of musical vibrations upon the magnetic needle, and I have shown the controlling influence of a purely mechanical polarity.‡ A careful examination of the polarizing thermal and rotation currents,§ will show that the spirals, which they have a tendency to produce, are quasi horizontal cyclones, one set flowing in a nearly constant direction along the magnetic meridian, and the other towards the momentarily shifting solar meridian. The communication of "Torricelli" referred to but one or two of the relations under which these eddies may be viewed; there are others, some of which are perhaps even more curious; and, from the examinations which I have already made, I have deduced the following theses:

I. The daily magnetic variations, though subject to great disturbances, at different hours, show an average approximation to the differences of the gravitation-tidal currents.

Hours from Mean, ...	1h.	2h.	3h.
Means of Theoretical Ratios, . .	.500	.866	1.
" " Observed " . . .	.563	.865	1.

II. Marked indications of an accelerating force are discoverable in the magnetic fluctuations, especially during the hours when the sun is above the horizon.

Hours from Mean, ...	1h.	2h.	3h.
Mean Ratios of Hourly Tidal Differences,	100	73	27
" " " Squares of Hourly Magnetic Differences,	100	74	26

See also Thesis V.

III. There are lunar-monthly barometric and magnetic tides, which may be explained by differences of weight or momentum,‖ occasioned by the combined influences of solar and lunar attraction, and terrestrial rotation.

IV. The solar-diurnal variations of magnetism between noon and

* See De la Rive's Electricity, v. ii, p. 635.

† Phil. Mag. [4], 13, 222.

‡ Ante, p. 359.

§ Ibid., p. 367 sqq.

‖ I believe there can be no weight without some degree of momentum. See Proc. A. P. S., vol. ix, p. 357.

midnight are nearly identical in amount with the variations of weight produced by solar attraction at the same hours.

The ratio of the solar to the terrestrial attraction for any particle at the earth's surface, being directly as the mass, and inversely as the square of the distance ($M \div R^2 = 354,936 \div 23,000^2$), is .00067. The weight of any particle is therefore increased by this proportionate amount at midnight, and diminished in the same proportion at noon, making a total half-daily variation of .00134 in the atmospheric weight, and consequently, according to my theory, in the terrestrial magnetism.

Theoretical variation, .00134. Observed variation, .00138.

V. The magnetic variations at intermediate hours, between noon and midnight, indicate the influences of an accelerating force, like that of gravity, modified by fluctuations of temperature and by atmospheric or ætherial currents.

Every particle of air may be regarded as a planet revolving about the sun in an orbit that is disturbed by terrestrial attraction and other causes. In consequence of these disturbances, there is an alternate half-daily fall towards the sun, and rise from the sun. By the laws of uniformly accelerated and retarded motions, the mean fall, and the consequent mean magnetic disturbances should occur at $12h. \div \sqrt{2} = 8h.\ 29'$ from midnight.

Theoretical mean, 8h. 29′. Observed mean, 8h. 31′.

VI. Some of the magnetic influences appear to be transmitted instantaneously, through the rapid pulsations of the kinetic æther,—others gradually, through the comparatively sluggish vibrations of the air.

VII. The comparative barometric disturbances of the sun and moon exhibit an approximate mean proportionality between their comparative differential-tidal and magnetic disturbances.

Let the solar differential-tidal force be represented by A', and the lunar by A'', the respective barometric disturbances by B' and B'', and the magnetic disturbances by M' and M''. If M' and B'' are required, we have

	$A' \div A''$	B'	B''	M'	M''
Theoretical values,			.00012	.00144	
Observed "	2.55	.00057	.00013	.00140	.0000255.

VIII. The theoretical gravitation-variation of magnetism (Prop. IV) is slightly less, while the theoretical barometric variation (Prop.

VII) is slightly greater than the corresponding observed variation. The excess in one case exactly counterbalances the deficiency in the other, the sum of the theoretical being precisely equal to the sum of the observed variations.

IX. The total daily magnetic variations, like the barometric, can be resolved into a variety of special tides, which may be severally explained by well-known constant or variable current-producing and weight-disturbing forces.

	A	B	A+B	
Hours from Midnight.	Theoretical Gravitation Tide.	Theoretical Differential Solar Tide.	Theoretical Mean Tide.	Observed Mean Tide.
0	—.00067	+.00024	—.00043	—.00043
6	.00000	—.00024	—.00024	—.00023½
12	+.00067	+.00024	+.00091	+.00095

The hours are counted from midnight, in each half-day.

Column A contains the hourly differences from mean weight, attributable to solar gravitation, with changed signs; diminution of weight being accompanied with increase of magnetism, and *vice versa*.

The form of the tide in column B is evidently such as should be determined by solar action. The magnitude of the tide is estimated by comparing the relative amounts of motion down the diagonal and down the arc of a quadrant $(.00067\times[1-(\frac{\pi}{4}-\frac{1}{2})]=.00048)$. The mean-tidal difference $[(.00067-.00048)\div2]$ is very nearly equivalent to the average theoretical inertia-disturbance of weight. The atmospheric inertia at St. Helena, (regarding the fluctuations as uniform between successive hourly observations), produces retardations of 59′, 85′, 26′, and 31′, at 0h., 6h., 12h., and 18h., respectively. The mean retardation is 50′, or $\frac{5}{72}$ of a half-day. The theoretical daily gravity-variation being .00134, the average variation in $\frac{5}{72}$ of a half-day is $.00009\frac{11}{36}$, the mean tidal difference being .00009½.

The consideration of the moon's disturbance of the atmospheric gravitation, is complicated by the magnitude of its differential attraction, the position of the centre of gravity of the terrestrial system, the varying centrifugal force, and other circumstances involved in the lunar theory. Still there are indications in the following synopsis, of the influence of gravity, sufficiently striking to encourage a hope that our knowledge of the moon's perturbations may be improved by a thorough comparative study of the lunar a tronomical, atmospheric, and magnetic tables.

LUNAR-DAILY DISTURBANCES OF MAGNETIC FORCE AT ST. HELENA, IN MILLIONTHS OF THE TOTAL FORCE.

Hours.	0	1	2	3	4	5	6	7	8	9	10	11	12
Before Lunar M.	+5	—1	+4	—2	—5	—5	—6	—3	—2	—1	+14	+15	+16
After " "	+5	—1	—5	—6	—7	—6	+1	+1	—2	+18	+25	+22	+16
Mean.	+5	—1	—0.5	—4	—6	—5.5	—2.5	—1	—2	+8.5	+19.5	+18.5	+16
Rotation-Tide.	0	0	±4.5	±2	±1	±.5	∓3.5	∓2	0	∓9.5	∓5.5	∓3.5	0

The above table shows, that

1. The moon's attractive force ($M \div R^2 = .016 \div 60^2 = .000004$) multiplied by the coefficient of its differential attraction (2.55) gives .0000113, which is nearly the same as the mean meridional magnetic disturbance [$(.000005 + .000016) \div 2 = .0000105$].

2. The increase of magnetism at 12h. is nearly equivalent to the attractive force, multiplied by the square of the distance from the centre of gravity of the system, and divided by the square of the earth's radius ($.000004 \times 7707^2 \div 3963^2 = .0000168$).

3. There is a tendency to equality of disturbances on each side of the meridian at 1h. and 8h., as in the solar magnetic tide.

4. The greatest disturbance occurs at the hours of 10h. and 11h. P.M., both in the solar and in the lunar tide.

5. There are some indications of an increase of gravity and decrease of magnetic force when the tidal flow is towards the centre of gravity of the terrestrial system, and *vice versa*.

6. The rotation-tide has the customary quarter-daily phases of alternate increase and diminution.

X. The phenomena of magnetic storms indicate the existence of controlling laws, analogous to those which regulate the normal fluctuations. See Proceedings Amer. Philos. Soc., Oct. 21, 1864.

The foregoing comparisons have been based on General Sabine's discussions of the St. Helena records. It would be desirable, if it were possible, to confirm them by observations at other stations near the equator, but the need of such confirmation is in great measure obviated by the variety of ways in which I have shown the probable connection of gravity and magnetism. At extra-tropical stations, the rotation tide becomes so preponderating that it is difficult to trace the diminished gravitation- and differental-tides, still I shall look confidently to a fuller development of the theory of tidal action, for future additional support to my views.

Pending nomination No. 529, and new nominations Nos. 530, 531, 532, 533, were read.

The annual report of the Finance Committee was read, and the appropriations for the ensuing year, recommended by the Committee were, on motion, ordered to be made, as follows:

Salary of Librarian, ...	$700 00
Assistant to the Librarian, ...	360 00
Petty expenses of Library, ...	50 00
Janitor, ...	100 00
Binding, ...	150 00
Journals, ...	50 00
Hall account, ...	200 00
Insurance, ...	200 00
Publications (in addition to the interest of Publication Fund), ...	800 00
Commissions to Treasurer and all other incidental charges, ...	590 00
	$3200 00

After which the Society was adjourned.